

## WHAT IS CLAIMED IS:

1                   1.       A method for controlling injection rate and injection pressure  
2 of a liquid fuel injector having a nozzle assembly, a pressure balanced control valve  
3 assembly including a valve body with a valve bore defining a valve seat, a movable  
4 valve element in the valve bore with a valve head in the movable valve element  
5 engageable in abutting relationship with the valve seat, the movable valve element  
6 being subject to pressure developed by the fuel injector during an injection event,  
7 the valve seat and the valve head defining a fluid pressure spill passage for a  
8 pressure regulated nozzle passage communicating with the nozzle assembly when  
9 the valve head is disengaged from the valve seat, and a solenoid actuator for the  
10 movable valve element; the method comprising the steps of:

11                   providing a first level of regulated current to the solenoid actuator to  
12 activate the movable valve element causing the valve head to abut the valve seat to  
13 partially seal the spill passage with a first sealing force thereby allowing regulated  
14 pressure in the nozzle assembly to rise and creating an initial injection rate-  
15 controlled period;

16                   providing a reduced level of regulated current to the solenoid actuator  
17 at a preselected time during the injection event to reduce the sealing force on the  
18 valve element thereby creating a reduced initial injection pressure during the initial  
19 injection rate controlled period; and

20                   providing a second level of regulated current at a value to cause the  
21 valve head to abut the valve seat to effectively seal the spill passage with a sealing  
22 force that allows regulated pressure in the nozzle assembly to rise further and to  
23 create a peak injection pressure near the end of the injection event.

1                   2.       The method set forth in claim 1 wherein the step of providing  
2 a second level of regulated current includes the step of maintaining the second level  
3 of regulated current for a preselected injection period as the peak injection rate  
4 controlled period is maintained near the end of the injection event.

1                   3.       The method set forth in claim 2 wherein the step of  
2 maintaining the second level of regulated current for a preselected injection period

3 is followed by the step of controlling depressurization of the nozzle assembly at the  
4 end of the peak injection rate controlled period.

1 4. The method set forth in claim 3 wherein the step of  
2 maintaining the second level of regulated current for a preselected injection period  
3 is preceded by a step of increasing the regulated pressure at a controlled rate  
4 following the initial injection rate controlled period.

1 5. The method set forth in claim 3 wherein the step of controlling  
2 depressurization of the nozzle assembly comprises the steps of reducing the level of  
3 current to a first lower depressurization control level following the step of  
4 maintaining a the second level of regulated current for a preselected injection period  
5 and reducing the level of current further to a second lower depressurization control  
6 level thereby terminating the injection event.

1 6. The method set forth in claim 4 wherein the step of controlling  
2 depressurization of the nozzle assembly comprises the steps of reducing the level of  
3 current to a first lower depressurization control level following the step of  
4 maintaining the second level of regulated current for a preselected injection period  
5 and reducing the level of current further to a second lower depressurization control  
6 level thereby terminating the injection event.

1 7. A method for controlling injection rate and injection pressure  
2 of a liquid fuel injector having a nozzle assembly and a pressure-balanced control  
3 valve including a solenoid and a valve element subject to pressures developed by the  
4 injector and actuated by the solenoid to apply a sealing force on the valve for  
5 metering fuel to the injector nozzle assembly, the valve controlling the injection  
6 pressure between an initial pressure and a maximum pressure, said method including  
7 the steps of:  
8 providing a first level of current to the solenoid for moving the valve  
9 from an open position toward a closed position allowing injection pressure to rise;  
10 providing a reduced level of current to the solenoid during initiation  
11 of the injection pressure to slightly reduce the sealing force on the valve, thereby

12 regulating the pressure to control the rate of injection of the fuel in an initial  
13 injection rate-controlled period;  
14 providing an increased level of current to the solenoid for moving the  
15 valve toward its closed position to effect increasing pressure regulation;  
16 providing a level of current to the solenoid when injection pressure  
17 is at a peak injection pressure value during a peak injection rate-controlled period  
18 to apply a sealing force on the valve thereby regulating a maximum pressure in the  
19 injector;  
20 providing a further reduced level of current to the solenoid at the end  
21 of the peak injection rate-controlled period to slightly unseat the valve thereby  
22 regulating depressurization of the injector; and  
23 ending solenoid current delivery thereby moving the valve to its open  
24 position.